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THE CLASSIFICATION OF AMERICAN GLACIAL DEPOSITS.

THE admirable delineation of the glacial deposits of Europe presented by Dr. Geikie in the foregoing paper invites a brief sketch of the American series for purposes of comparison.[1]

Our knowledge of the formations that were deposited during the advancing stages of the glacial period in America is extremely imperfect. Owing to the erosions of the overriding ice and the burial of the residue it is likely always to remain meager. There have been found, however, here and there, remnants of drift which have the appearance of superior age and of separateness from the overlying deposits, and which may therefore represent the accumulations of the earlier stages of the glacial period, but none of these seem as yet entitled to distinct recognition. We would appear, therefore, to have nothing which can be correlated with confidence with the Scanian horizon of Europe, as defined by Dr. Geikie.

A similar observation is to be made respecting the deposits of a stage possibly equivalent to the Norfolkian. In some localities beds of peat and vegetal débris, with accompanying earthy deposits, have been found underneath the lowest drift at the points in question, but I am not aware that there is any specific ground for connecting them immediately with the glacial period. It can simply be said of them that they were accumulated earlier than the earliest known glacial invasion, but whether the accumulation was immediately antecedent (and so contemporaneous with some of the advancing stages of glaciation, or with some of the deglaciation stages that may have interrupted the advance), or whether it was more distantly antecedent, is an altogether open question. The perishable nature of such deposits offers some presumption that they were not very greatly antecedent to the maximum ice invasion, and, to that slight extent, offers a presumption that they were contemporaneous with the earliest stages of the glacial period in the larger application of the term.

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[1] In the recent edition of "The Great Ice Age," an outline of the American glacial deposits was given to which the writer begs to refer for some characterizations of the members of the series here omitted or abbreviated. In that sketch the names Kansan, East Iowan and East Wisconsin were given to the three leading till sheets, as at present known, and the Toronto fossil beds were recognized under that name as an important interglacial deposit. Other interglacial deposits were not named, nor the latest members of the glacial series, which would be necessary to carry out a complete parallelism with the elaborate series of Dr. Geikie. Mr. Upham has made the suggestion that the terms East Iowan and East Wisconsin be abbreviated to Iowan and Wisconsin, which is cheerfully accepted, so far as it may be done without danger of misunderstanding.

The Kansan formation (=*Saxonian ?*).—The earliest formation which has been worked out into sufficient definiteness to merit specific recognition in the United States is an expansive sheet which reaches southward nearly to the junction of the Ohio and the Mississippi and southwesterly beyond the Missouri. The term Kansan has been applied to it because of its great extent in the direction of the arid plains and because it appears in the State of Kansas free from complications with other formations. It consists essentially of a sheet of till with associated assorted drift. Only the assorted material which was essentially contemporaneous with the till is here included. That which overlies it and was not formed at the same time is referred to the succeeding horizon.

There is a striking similarity between the Kansan formation and the Saxonian of Dr. Geikie. They both alike represent the greatest extension of the ice sheet. They are alike in terminating in an attenuated and worn border, in the main. They are neither corrugated by great peripheral moraines, as a rule, nor by longitudinal drumloidal ridges, nor, in general, by great esker systems, or kame aggregations. None of these features are entirely absent, but they have a relatively inconspicuous development. The relations of the two to succeeding formations are essentially identical.

While no correlation across so great an interval as the Atlantic can command the utmost confidence until the cause of glaciation shall have been demonstrated, and shall have been shown to be such as to operate in like ways on both continents at the same time, it is nevertheless interesting to make such correlation as the formations permit, and it may be profitable if held in due restraint. The parallelism between the Kansan and the Saxonian formations is fairly close and certainly suggestive.

The Aftonian (=*Helvetian?*).—Subsequent to the formation of the Kansan sheet of till, and accompanying assorted deposits, there was a very notable retreat of the ice. Mr. Upham, whose inclination to unify and limit the extent of the glacial period makes his judgment especially valuable on this point, expresses the opinion that the retreat reached an extent of 500 miles.[1] This judgment is based upon the occurrence of interglacial peaty deposits in the basin of Lake Agassiz. If we recognize a subsequent retreat of considerable moment between the Iowan and Wisconsin stages, it will not perhaps be clear that these deposits do not belong to the later interval; but even under this interpretation, the retreat must still probably have exceeded 300 miles. During this stage of retreat there were accumulations of muck and peat reaching a reported depth of twenty-five feet. One of the best exposures of this horizon is found between Afton and Thayer, Iowa, and from the former a euphonious name may be taken. Owing to the scarcity of gravel in the drift territory of southern Iowa, the Chicago, Burlington & Quincy Railway has made very extensive excavations upon three gravel deposits lying between an upper sheet of till reaching a thickness of forty to sixty feet and a lower till of less depth. The gravels appear to be kame-like accumulations, at least they are great lenses lying upon the surface of the lower till. This lower till is believed to belong to the Kansan stage and the upper to the Iowan. On the surface of the gravels there accumulated, at points, a deep mucky soil, in which occur considerable quantities of vegetal débris. This is believed to occupy the same horizon as the numerous peaty deposits described by McGee in eastern Iowa.[2] To this horizon also is referred the peat beds lying between the two outer till sheets of southeastern Minnesota, described many years ago by Professor N. H. Winchell.[1] The fauna and flora of this horizon have not yet been adequately worked out, but their general indications are not unlike those of the Helvetian stage of Europe, as defined by Dr. Geikie. A tentative correlation of the two may therefore be made.

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[1] WARREN UPHAM: Am. Naturalist, Vol. XXIX., 1895, March, p. 237.

[2] Eleventh Annual Report U. S. Geological Survey, p. 487.

The Iowan formation (=*Polandian?*).—This embraces an extensive sheet of till lying upon the preceding interglacial deposits and having its best known expression in eastern Iowa, where it has been most carefully worked out by McGee. It is known to have considerable extension in adjoining states, but its full distribution is not yet ascertained. It is intimately associated with the most important of the loess deposits. In some places it appears to graduate at its edge into loess which spreads far away from its border. In other places, it seems to pass up by graduation into a loess mantle. To avoid misunderstanding it should be remarked that minor deposits of loess are associated with other sheets of drift, and loess is not necessarily characteristic of any horizon. The close association of the greatest loess deposits with the Iowan formation is, however, significant of the conditions under which it was formed.

The Iowan formation stands in a relation to the American series similar to that of the Polandian to the European series. It has, furthermore, similar characteristics in constitution and surface expression. I believe I am correct in saying that the chief loess deposits of south Germany and Russia are associated with the Polandian formation in much the same way that the chief loess of the Mississippi basin is associated with the Iowan deposits. In a tentative correlation, therefore, the Iowan and the Polandian formations may plausibly be regarded as equivalents.

The Toronto formation (=*Neudeckian?*).—Through the recent investigations of Coleman[2] and others, and the earlier studies of

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[1] N. H. WINCHELL: Proc. A. A. A. S., Vol. XXIV., 1875, Pt. II., pp. 43–56; Geol. Minn., Final Rep., Vol. I., 1884, pp. 313, 363, 390.

[2] A. P. COLEMAN: Interglacial Fossils from the Don Valley, Toronto. Amer. Geologist., Vol. XIII., February, 1894, pp. 85–95.

Hinde,[1] it has been shown that there is a very important series of fossiliferous beds in the vicinity of Toronto, interstratified between till sheets. There are two series of fine laminated shales and sandstones separated by a sheet of till, with till overlying the whole, and presumably also underlying the whole. In the lower stratified series, whose thickness Dr. Hinde gives as 140 feet, the silts and sands contain organic remains from bottom to top. These embrace a considerable variety of forms, the most notable of which are the remains of lepidopterous insects, all of which have been pronounced by Scudder to be extinct. These beds are exposed on the face of Scarborough Heights a few miles east of Toronto. Along the river Don, in the immediate suburbs, Professor Coleman has found a remarkable group of molluscan forms and of plants in laminated clays and sands that were at first supposed to be equivalent to the fossiliferous series of Scarborough Heights. But Professor Coleman informs me that he has reasons for doubting the correctness of this correlation, and thinks it not impossible that the beds on the Don may correspond to the upper clays and shales in the Scarborough section. If this should prove true (and this statement should not be construed as in any way committing Professor Coleman) we shall have here two fossiliferous series requiring correlation. The series on the Don contain molluscan forms, chiefly unios and their relatives, which belong to the Mississippian, rather than to the Atlantic, drainage area. They also contain plants that indicate a more genial environment than that of Toronto at present. From the fact that the molluscan forms appear to have passed over the divide between the Mississippi and the St. Lawrence basin after the retreat of the earlier ice, and to have been subsequently forced out of the basin, presumably by the return of the ice, which formed the overlying till sheet, it has seemed possible, if not probable, that the beds upon the Don belong stratigraphically between the Iowan and the overlying Wisconsin beds. It will be observed that the grounds for this correlation are not very strong, and investigation may show them to be erroneous. It is not likely, however, that the beds upon the Don can be referred to any earlier period. They may be later. Should the beetle-bearing beds at the base of Scarborough Heights prove to be distinct from the molluscan beds on the Don, the former may perhaps be found equivalent to the Aftonian beds previously described. Whether the beds on the Don belong to the horizon suggested or not, it is certain that vegetal beds were formed in the interval of the retreat between the formation of the Iowa till and the formation of the Wisconsin till, and some of these less well developed and less known deposits must be looked to as a type of this interglacial horizon, if the Toronto beds prove unavailable.

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[1] GEORGE JENNINGS HINDE: The Glacial and Interglacial Strata of Scarborough Heights and other localities near Toronto, Ontario. Can. Jour., April, 1877.

If the fossiliferous clays and shales on the Don belong to the interval between the Iowan and Wisconsin formations, they may be tentatively correlated with the Neudeckian of Geikie.

The Wisconsin formation (= *Mecklenburgian* ?).—Overlying the interglacial beds above the Iowan deposit, comes the most massive of the American till sheets, occupying the larger part of the territory of the northern states and very large sections of Canada. This is distinguished by a series of gigantic terminal moraines, stretching across the country in an undulatory fashion already well known to students of the subject. There are at least two divisions of the moraine-bordered tills, with a somewhat notable interval between the two, during which there was considerable rearrangement of the frontage of the ice. As a result of this, some of the later moraines run at large angles across the earlier ones, riding over them in a quite disregardful fashion.

In like manner there occurs upon the northern plains of Germany a series of similar gigantic moraines associated with thick till sheets. There are also pronounced but less massive moraines in southern Scandinavia and Finland. The two series are interpreted as representing a single stage by Dr. Geikie, but to one at a distance, and without personal familiarity with deposits, the suggestion that they represent two episodes having some such relation to each other as the two subdivisions of the

Wisconsin formation arises, and may be mentioned for what it is worth, which is probably very little. The chief characteristics of the European morainic series are strikingly similar to those of the American, as long since pointed out by Salisbury.[1] In addition, therefore, to the similarity of position in the European series which the Mecklenburgian series bears to that of the Wisconsin formation in the American series, there is a striking correspondence in the individual characteristics of the two. Beyond any question these individual characteristics were due to some common condition or combination of agencies. If the fundamental cause of glaciation was such as to involve intercontinental contemporaneity of action, the correlation of the two has much in its support.

Later deposits.—Investigation in America has gone far enough to make it certain that subsequent to the deposit of the Wisconsin formation, there was a somewhat complex series of events before the Ice Age entirely passed away. It has not, however, gone far enough to make it clear precisely what the stages were, and it is perhaps premature to attempt to designate the specific formations which resulted. A series of beach lines along the lower lakes has been specifically connected with moraines by Leverett and others, indicating a coincidence of lake action and ice action. On the north side of the lakes it is known that there are several very considerable terminal moraines indicating at least halts, and possibly advances, of the ice subsequent to its retreat from the territory of the United States. It is every way probable that some of these will deserve a special taxonomic place when sufficiently traced out. If the fossiliferous beds of Toronto are later than the Wisconsin formation, they and the overlying till certainly merit special recognition. There is therefore abundant room for the belief that stages of action equivalent to the Turbarian and Forestian of Dr. Geikie may be found.

In carrying out this parallel, it has not been the design of the writer to indicate a judgment respecting the specific value of the several formations, either in terms of taxonomy or chronology. It has been thought, however, that it would promote a mutual understanding of the formations of Europe and America if some approximate equivalence could be shown between the two unquestionably complex series. It will perhaps promote the differentiation of the two series to institute mutual comparisons, and it may facilitate a final judgment of the value of these subdivisions if we are able to compare, formation by formation, the distant series with that which falls within our own field of investigation.

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[1] R. D. SALISBURY: Terminal Moraines in Northern Germany. Am. Jour. Sci., 3d series, Vol. 35, 1888, pp. 401–407.

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